Bulked Genetic Characterization of Ghanaian Maize Landraces

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INTRODUCTION

Maize (*Zea mays* L) was first introduced into Africa via Ghana and the Sao Tome islands by Portuguese traders in the 16th century (Shepherd et al., 2010). In Ghana, the phenotypic diversity of the crop is quite impressive and it includes ears with purple, red, yellow/orange, variegated or white kernels, in flint and dent consistencies. Cultivated maize is dominated by open pollinated varieties (OPVs) and landraces with few hybrids. Studies of molecular characterization and population structure of African landraces are few. Considering the importance of maize cultivation in Ghana, this knowledge gap is a crucial limiting factor. Understanding relationships among maize landraces may provide clues as to why Ghanaian landraces are so low yielding, and hasten cultivar improvement and adoption. Here, SSR markers and a bulked population fingerprinting technique were used to characterize molecular diversity and relationships among maize landraces collected throughout Ghana.

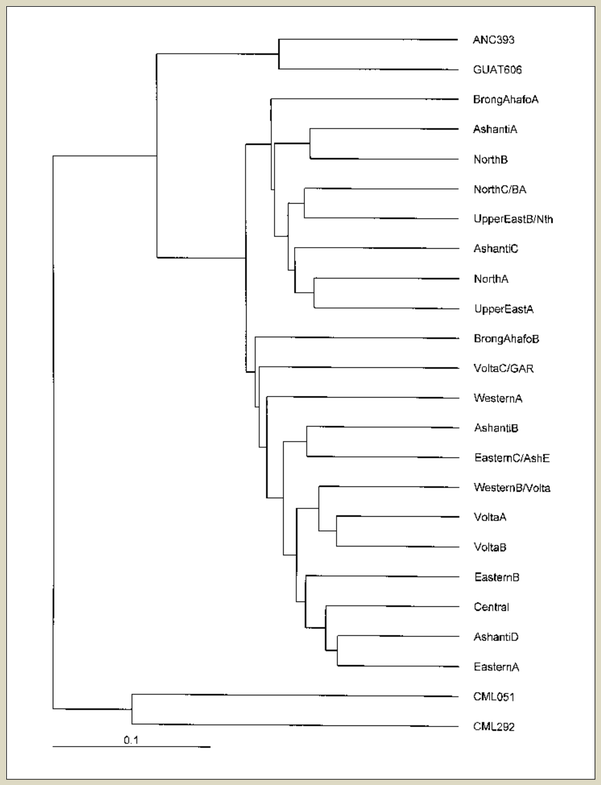
METHODS

Over 500 maize populations were collected in 2007 from farmers across Ghana who cultivate landraces. A subset of 20 populations was chosen to represent the geographical diversity within the country (Table 1). Four entries (CML051, CML292 from CIMMYT, ANC 393 from Peru and GUAT606 from Guatemala) were used as unrelated controls. The bulked fingerprinting technique was used to characterize the OPVs at the ABC laboratories at CIMMYT, Mexico. DNA was extracted from bulks of fifteen screen house grown plants per population 2 weeks after planting using the CTAB method. Twenty SSR markers spanning the genome were used to amplify products from bulked DNA, which were run on an automatic DNA sequencer (ABI 3100). Allele frequencies of each bulk were calculated from peak heights. Diversity statistics and distances were calculated in PowerMarker and Structure 2.2 was used to analyse population structure and identify sub-groups within the Ghanaian maize populations.

Table 1. ID and origin of the landraces used in the study. Colors correspond to the Structure clusters in Figure 2.

Population	Major town/Locality	Longitude	Latitude	No. of cobs	Structure cluster
AshantiA	Bekwai	6° 27N	1° 35'W	38	
AshantiB	Lake Bosomtwe	6° 27' N	1° 24' W	30	
AshantiC	Ejura/Sekyedumase	7° 22' N	1°21'W	19	
AshantiD	Kwaso	6°50'N	1°30' W	22	
BrongAhafoA	Wenchi	7° ' 44N	2° '06 W	15	
BrongAhafoB	Goaso	6° 47' N	2° 30' W	21	
Central	Mankesim	5° 24' N	1° 09 W	18	
EasternA	Anum	6° 13' N	0° 04'E	24	
EasternB	Akuapim ridge	5° 51' N	0° 20'W	20	
EasternC/AshE	Adawso/Essumeja	5°56 ' N	0° '12 W	29	
NorthA	Nyankpala	9° 23' N	0° 59' W	36	
NorthB	Walewale	9° 25' N	0° 02' E	31	
NorthC/BA	Tamale/kintampo	9° 24' N	0° 51'W	24	
Upper EastA	Navrongo/Paga	10° 59' N	1° 06 W	25	
Upper EastBNorth	Bawku/Kpana	11° 11 ' N	0° 61' E	27	
VoltaA	Kpeve	6° 40' N	0° 20' E	30	
VoltaB	Ohawu	6° 07' N	0° 47' E	28	
Volta/GAR	Golokwati/Ayimensa	5° 50' N	0° 10' W	25	
WesternA	Babiani	6° 27' N	2° 19' W	27	
WesternB/Volta	Axim/Ho	4° 52'N	2° 14' W	27	
Anc393	Peru	9° 37'N	77° 33'	n/a	n/a
GUAT606	Guatemala	14° 28'N	90° 10'W	n/a	n/a
CML051	CIMMYT Mexico	19° 25'	99° 10'W	n/a	n/a
CML292	CIMMYT Mexico	19° 25N	99° 10'W	n/a	n/a

Figure1. UPGMA dendrogram showing relationships between 20 Ghanaian maize landraces and 4 controls created using the shared allele genetic distances between all pairs of populations in Powermarker.



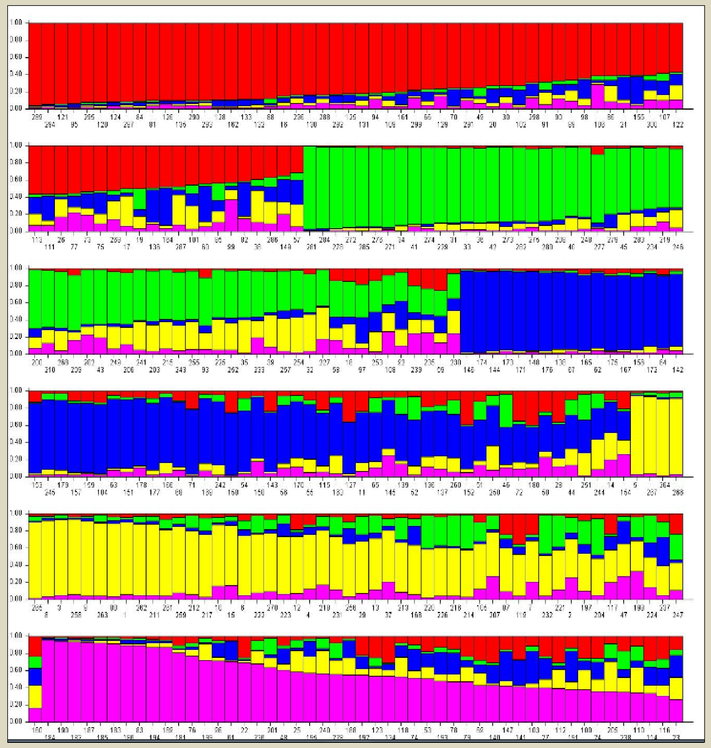


Figure 2. Clusters of Ghanaian maize landraces created by Structure. Each column corresponds to one individual from one of 20 populations. Different colors represent different clusters. The color of each column represents the probability of belonging to that cluster; each individual may be composed of variation from more than one cluster.

RESULTS AND CONCLUSIONS

All SSR markers were polymorphic. F statistics indicate that populations are not well differentiated, and thus probably contain a mixture of different germplasm; however, they are distinct enough to differentiate in the Structure analysis. This is common in maize populations, which are out-crossing by nature, and farmers often exchange seeds of their best populations. Mixing thus occurs via pollen and seed flow. The cluster analysis (Fig. 1) grouped the Ghanaian maize landraces into two main, well differentiated groups: a northern group corresponded to the Guinea savannah zone, which is drier, has a single rainy season and a southern group corresponding to the forest and coastal savannah, which receives more rainfall and has two growing seasons. Ashanti landraces, occur in both clusters. Ashanti is centrally located in Ghana and it is one of the main centres of the maize business. Farmers from all over the country converge here to trade and may be why germplasm from Ashanti fall within the major groups. Similarly, the vegetation in Ashanti is both forests with some portions being forest/savannah type, which may also contribute to the mixing of populations from here within the dendrogram.

Baysian clustering found a slightly different pattern (Fig. 2) of five clusters with a less discrete nature (more in accordance with the analysis of F statistics). Structure cluster colors in Fig. 1 correspond to colors in Table 1. In addition , the speculative nature of maize trade brings about movement of germplasm from north to south, east to west, and vice-versa. Since most farmers are small landholders and often unable to save their own seeds, they buy from the traders in the open market for planting and select then genotypes they prefer for cultivation in the subsequent seasons. The Structure analysis may reflect how this different maize germplasm has spread across Ghana, sometimes to places where they were not intended and show sub- optimum yield and productivity. Extension officers and farmers should be informed of landrace relationships to better advise farmers to grow suitable cultivars for higher productivity in specific climatic zones.

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